Taking on Smog

Expanded Options for Controlling Nitrogen Oxides

- Nitrogen oxides (NO_x) became the focus of a series of regulatory actions to severely limit emissions after having been identified as a source of both acid rain and urban smog. Coal-fired boilers represent a primary source of NO_x emissions and a specific target of regulatory action.
- Prior to the Clean Coal Technology Demonstration Program (CCT Program), NO_x control technology proven in U.S. utility service simply did not exist. Today that situation has changed dramatically. The CCT Program has met the regulatory challenge by forging emerging NO_x control technologies into a portfolio of cost-effective regulatory compliance options for the full range of boiler types.
- The resultant technology portfolio and associated databases and experience have:
  - Provided real-time data in formulating regulatory provisions;
  - Built the foundation for meeting NO_x emissions limits well into the 21st century; and
  - Positioned U.S. industry to export NO_x control technology.
- Products include:
  - Low-NO_x burners and reburning systems that modify the combustion process (combustion modification) to limit NO_x formation;
  - Selective catalytic and non-catalytic reduction technologies (SCR and SNCR) that act upon and reduce NO_x already formed (post combustion processes); and
  - Artificial intelligence-based control systems that effectively handle numerous dynamic parameters to optimize operational and environmental performance of boilers.
- As a result of the CCT Program, nearly one-half of U.S. coal-fired generating capacity has installed low-NO_x burners, with sales to date exceeding $1.5 billion. Reburning and artificial intelligence-based control technologies have made significant market penetration as well. All demonstration sites have retained the technologies for commercial use.

"Our experience with the Clean Coal Program allowed us to make informed decisions on how to best control NO_x emissions throughout our four-state service area. It has saved our customers millions of dollars."
Randall Rush
Southern Company Services, Inc.

Low-NO_x burners control the mixing of fuel and air during combustion. Reburning systems inject fuel into combustion products to strip oxygen away from the NO_x and introduce air above the reburn zone to complete combustion gradually in a cooler environment. Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) use chemicals to transform NO_x into nitrogen and water. Artificial intelligence controls measure key parameters and control their interactions to optimize performance against set values. The approaches can be combined to meet site-specific performance objectives.

LNCFS™ Low-NO_x Burner at Plant Lansing Smith

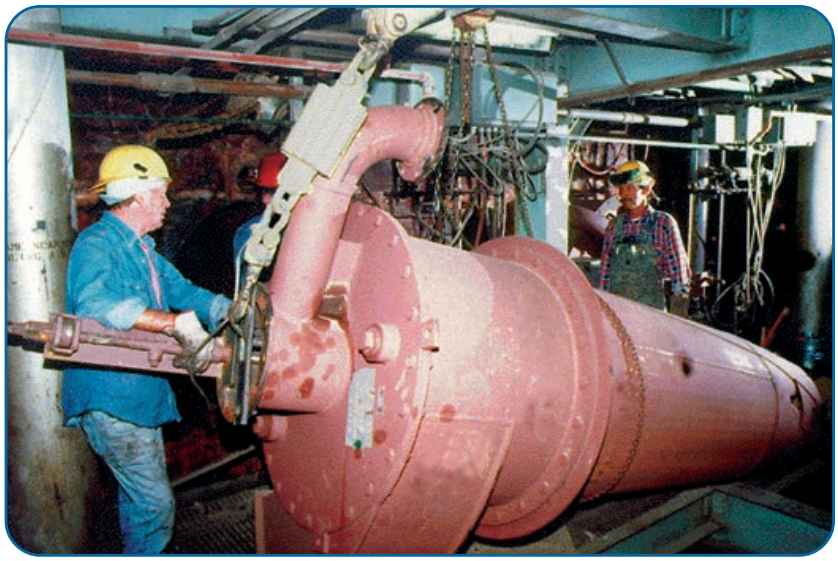
Low-NO_x Burners

ABB Combustion Engineering's LNCFS™ low-NO_x burner successfully completed demonstration at Gulf Power Company's Plant Lansing Smith, and at New York State Electric & Gas Corporation's (NYSEG) Milliken Station.

Utilities subsequently installed LNCFS™ and its derivative technology TFS 2000™ on an estimated 116 pulverized-coal tangentially-fired boilers, representing 25,000 MWe of generating capacity.

Tangentially-fired boilers constitute about 42 percent of the U.S. coal-fired capacity built before New Source Performance Standards (NSPS) were implemented. ABB Combustion Engineering is the primary manufacturer of tangentially-fired boilers. *(Demonstration sponsors: Southern Company Services, Inc. and NYSEG)*

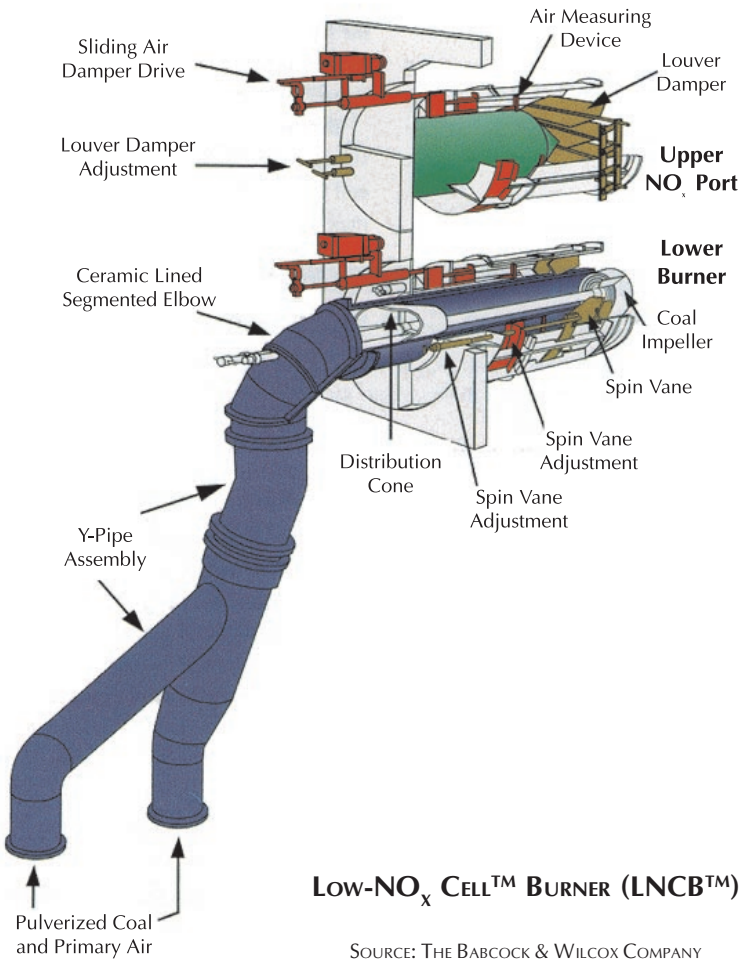
Dry bottom wall-fired boiler capacity in the U.S. approaches that of tangentially-fired boilers at about 37 percent. The two major wall-fired boiler manufacturers are The Babcock & Wilcox Company and Foster Wheeler. Both companies engaged in several successful demonstrations of their low-NO_x burners. Shown below is a Foster Wheeler burner being installed at Gulf Power Company's Plant Hammond. Foster Wheeler subsequently equipped 86 boilers with its low-NO_x burners (51 domestic and 35 abroad), totaling 1,800 burners for over 30,000 MWe of generating capacity. These installations have an estimated value of $35 million. The Babcock & Wilcox Company has signed contracts to equip 124 boilers with 2,428 DRB-XCL® burners, valued at $240 million and representing 31,467 MWe of generating capacity. *(Demonstration sponsors: Southern Company Services, Inc.; The Babcock & Wilcox Company; and Public Service Company of Colorado*)



Foster Wheeler Low-NO_x Burner installation at Plant Hammond

Babcock & Wilcox also developed and demonstrated a low-NO_x cell burner, LNCB®, for application to the highly efficient, but high NO_x emitting cell-burner boiler. Cell-burner boilers represent about 7.4 percent of the pre-NSPS coal-fired boiler population, but produce a disproportionately high percentage (about 11.3 percent) of the NO_x emissions.

The characteristic high heat release, causing the excessive NO_x emissions, precluded the conventional approach to modifying the burner for NO_x control. Successful demonstration of the LNCB® at Dayton Power & Light Company's 605-MWe J.M. Stuart Plant led to seven commercial contracts for 172 LNCB®s on 4,900 MWe of capacity valued at $27 million.



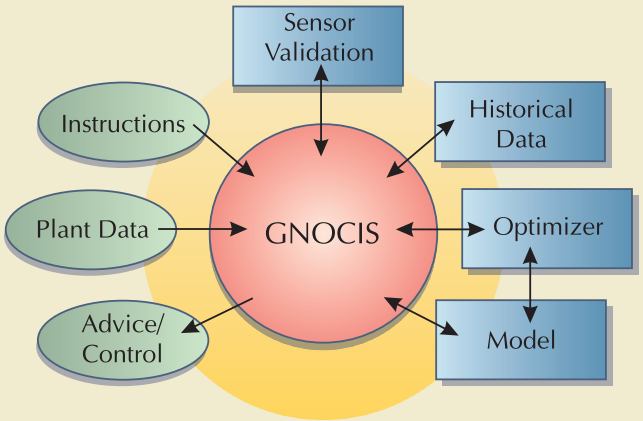
Low-NO_x Cell™ Burner (LNCB™)

Source: The Babcock & Wilcox Company

Advanced Control Systems

Advanced control systems are essential to handle the large number of parameters that must be controlled to effect optimum performance. Two artificial intelligence-based control systems proved their value through two separate demonstrations. The Electric Power Research Institute's Generic NO_x Control Intelligence System (GNOCIS) underwent successful demonstration at Gulf Power Company's Plant Hammond. GNOCIS installations are underway or planned at 26 commercial installations representing over 12,000 MWe of capacity. Below, the major elements of GNOCIS are illustrated, which are characteristic of artificial intelligence-based systems. DHR Technologies, Inc.'s Plant Emissions Optimization Advisor (PEOA™) proved enhanced performance at NYSEG's Milliken Plant. There have been six modules of the PEOA™ sold with an estimated value of $210,000 and bids are outstanding in Korea.

Major Elements of Generic NO_x Control Intelligent System (GNOCIS)



Natural gas injector at Hennepin Station

Coal pulverizer used to supply Babcock & Wilcox reburning system at Nelson Dewy Station

Reburning

Reburning is applicable to virtually any boiler type separately or in conjunction with low-NO_x burners because it works in association with the primary combustion process. But for cyclone boilers, reburning is the only combustion modification technology shown to be feasible for controlling NO_x emissions. The importance of having a NO_x control capability lies in the fact that cyclone boilers represent 8.5 percent of the pre-NSPS boiler population, yet contribute approximately 12 percent of the NO_x. The elevated NO_x levels are attributable to high combustion temperatures generated in the cyclones.

The Energy and Environmental Research Corporation (EER) successfully demonstrated gas-reburning on three boiler types. Demonstration sites include:

- City Water, Light & Power's 33-MWe Lakeside Station (cyclone);
- Illinois Power Company's 80-MWe Hennepin Plant (tangentially-fired); and
- Public Service Company of Colorado's 172-MWe Cherokee Station (wall-fired).

Gas-reburning crossed the commercial threshold with three installations in New York state and one in Colorado. Moreover, in late 1997 EER announced two major contracts to equip five cyclone boilers with gas-reburning for NO_x control. Use of the technology also extends to overseas markets. In 1993, one of the first installations of the technology took place at the Ladyzkin State Power Station in Ladyzkin, Ukraine.

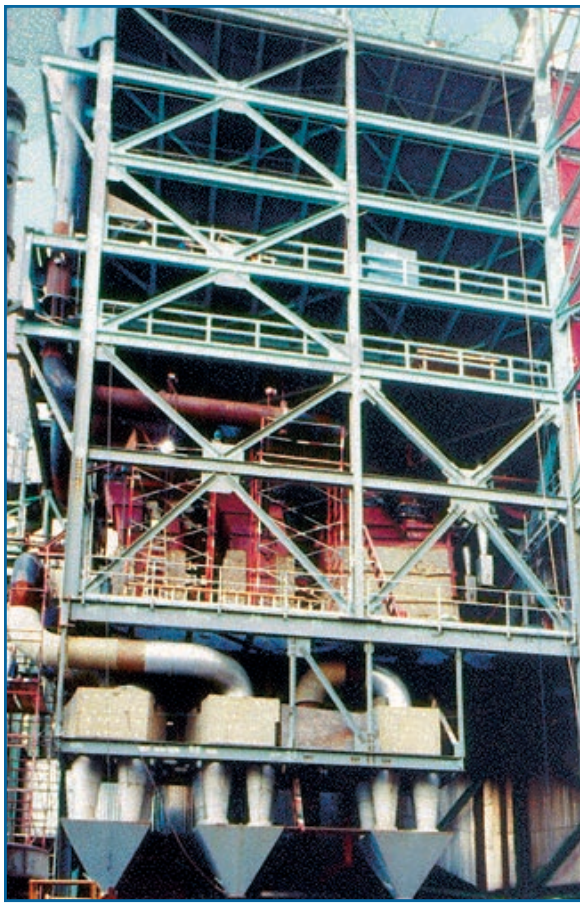
Babcock & Wilcox developed a project to prove the commercial viability of a coal-reburning system. The demonstration took place on a 100-MWe cyclone boiler at Wisconsin Power and Light Company's Nelson Dewy Station in Cassville, Wisconsin. Boiler modifications included provisions to inject up to 30 percent of the fuel as pulverized coal through reburn burners located above the primary combustion zone. In addition to achieving excellent NO_x control, the system avoided boiler derating when using low-rank coals because of the increased fuel feed capacity.

Post-Combustion NO_x Control

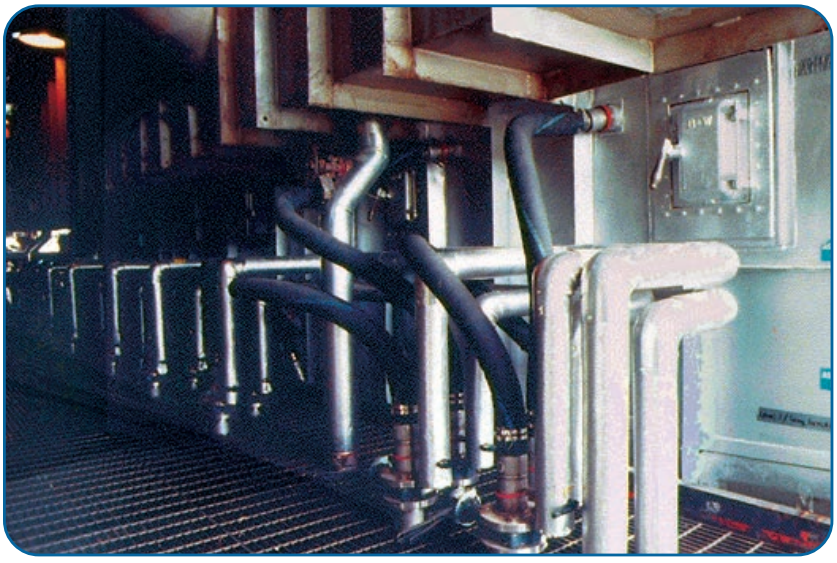
Although SCR had realized commercial acceptance abroad by the late 1980s, U.S. utilities were reluctant to consider SCR as a viable compliance option. Questions remained regarding performance with U.S. coals under U.S. operating conditions. To address these uncertainties, Southern Company Services' Gulf Power Company hosted SCR tests at Plant Crist near Pensacola, Florida. The tests evaluated eight commercially available catalysts with various shapes and chemical compositions to assess process chemistry and economics of operation. Both high- and low-dust loading conditions were tested.

The Gulf Power tests established SCR as a viable U.S. compliance option and aided utilities in developing the most cost-effective, site-specific applications of SCR.

The Public Service Company of Colorado evaluated SNCR, using in-furnace urea injection, in combination with low-NO_x burners, at its 100-MWe Arapahoe Station, Unit 4. The technologies proved to be complementary, achieving high levels of NO_x reduction.



Tests at Gulf Power Company's Plant Crist demonstrated that SCR can perform in accordance with design specifications under conditions reflective of U.S. utility operations.



SNRC installation at Arapahoe Station